# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-216605

(43)Date of publication of application : 04.08.2000

(51)Int.Cl. H01P 5/107
H05K 1/02

(21)Application number : 11-013004

(22)Date of filing : 21.01.1999

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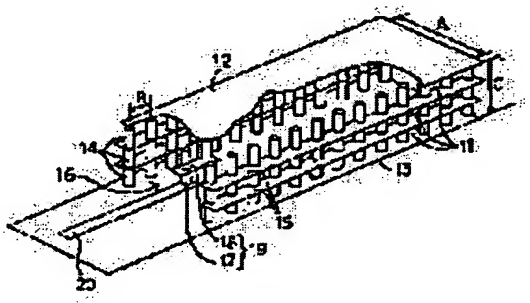
## (54) CONNECTION STRUCTURE BETWEEN DIELECTRIC WAVEGUIDE LINE AND HIGH FREQUENCY LINE CONDUCTOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a connection structure between a dielectric waveguide line and a high frequency line conductor that can connect the laminated dielectric waveguide line with the high frequency line conductor such as a microstrip line, a strip line or a high frequency line with an excellent characteristic even when a characteristic impedance of the dielectric waveguide line differs from that of the high frequency line conductor.




SOLUTION: The connection structure is used to connect a high frequency line conductor 20 with a dielectric waveguide line 16 by inserting an end of the high frequency line conductor 20 to an opening end of the dielectric waveguide line 16 consisting of a couple of main conductor layers 12, 13 having a dielectric board 11 inbetween and two rows of through-conductor groups 14 for sidewall that are formed between the main conductor layers 12, 13 at a prescribed interval with a prescribed width and of a sub conductor layer 15 and by electrically connecting the end of the high frequency line conductor 20 and one (12) of the main conductor layers 12, 13 with a connection use line conductor 18 and a connection use through-conductor 17 in a way of forming a step. Even when the characteristic impedance of the conductor 20 differs from that of the line 16, the connection structure connects the both with an excellent characteristic and since the thickness of the connection structure is thin, the connection structure can be miniaturized.

LEGAL STATUS

| | |
|---|---|
| [Date of request for examination] | 26.08.2002 |
| [Date of sending the examiner's decision of rejection] | |
| [Kind of final disposal of application other than the examiner's decision of rejection or application converted registration] | |
| [Date of final disposal for application] | |
| [Patent number] | 3517143 |
| [Date of registration] | 30.01.2004 |
| [Number of appeal against examiner's decision of rejection] | |
| [Date of requesting appeal against examiner's decision of rejection] | |
| [Date of extinction of right] | |

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CLAIMS

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[Claim(s)]
[Claim 1] In the initiative body whorl of the pair which pinches a dielectric substrate from the upper and lower sides, and the transmission direction of a RF signal, at intervals of less than 1/2 repeat of signal wave length and the penetration for side attachment walls of two trains which connected between said initiative body whorls in said transmission direction and the direction which intersects perpendicularly electrically, and were formed in it by predetermined width of face -- a conductor -- with a group Provide the subconductor layer electrically connected with the group, and it changes. it forms in an initiative body whorl and parallel between said initiative body whorls -- having -- said penetration for side attachment walls -- a conductor -- said initiative body whorl and the penetration for side attachment walls -- a conductor, while inserting the edge of the line conductor for RFs which transmits said RF signal to the opening edge of the dielectric-waveguide track which transmits a RF signal by the field surrounded by the group and the subconductor layer The line conductor for connection arranged in parallel in the same transmission direction as said line conductor for RFs in the edge of this line conductor for RFs, and one side of said initiative body whorl, the penetration for connection arranged in the edge of this line conductor for connection by intersecting perpendicularly -- the connection structure of the dielectric-waveguide track and the line conductor for RFs which are characterized by connecting electrically so that the shape of a stairway may be accomplished with a conductor.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the connection structure of the dielectric-waveguide track and the line conductor for RFs which can connect the dielectric-waveguide track which is the transmission line which transmits RF signals, such as a microwave band and a millimeter wave band, and line conductors for RFs, such as a microstrip line, by low loss.
[0002]
[Description of the Prior Art] In recent years, research of the mobile communications using RF signals, such as a microwave band and a millimeter wave band, the radar between vehicles, etc. is advanced briskly. As the transmission line for RFs for transmitting a RF signal in these RF circuits, line conductors for RFs, such as a coaxial track, a waveguide, a dielectric-waveguide track and a microstrip line, and the strip line, etc. are known conventionally.
[0003] Recently, since two or more arrangement of the RF track where classes differ is carried out into the wiring circuit which constitutes a RF circuit, the connection technique between these RFs tracks has become important, and various structures are proposed about the connection structure.
[0004] For example, with the connection structure of a waveguide or a dielectric waveguide, and a coaxial track, it connects by inserting the signal line of a coaxial track into a waveguide, and joining together in RF.
[0005] Moreover, with the connection structure of a waveguide and a microstrip line, when making a waveguide and a microstrip line intersect perpendicularly and connecting, the structure which inserts into a waveguide the dielectric substrate with which the microstrip line was formed is used. Moreover, when connecting a waveguide and a microstrip line in an parallel direction, the structure inserted in the interior of the so-called ridge waveguide which narrowed the line conductor of a microstrip line the shape of a curve toward the edge which connects is known.
[0006]
[Problem(s) to be Solved by the Invention] It continues till recently, and if a RF track is formed on the substrate with which a RF circuit is constituted, or in a substrate, since it will become advantageous in respect of a miniaturization, to form a dielectric-waveguide track with a laminating technique in the wiring substrate of multilayer structure is desired. For example, in JP,6-53711,A, a dielectric substrate is pinched by the initiative body whorl of a pair, and the waveguide track which formed the side attachment wall by the beer hall group arranged by two trains which connect between conductor layers further is proposed. the false conductor according [ this waveguide track ] the four way type of dielectric materials to the initiative body whorl and beer hall group of a pair -- surrounding with a wall -- a conductor -- Kabeuchi's field is made into the track for signal transmissions.
[0007] When mainly using the dielectric-waveguide track of the laminating mold arranged in the interior of such a multilayer-interconnection substrate as the transmission line of the ceramic multilayer-interconnection substrate for microwave and millimeter waves, or the semiconductor package for high frequency, connection with other high frequency circuits is needed.
[0008] On the other hand, the connection structure using electromagnetic association by the slot hole prepared in the initiative body whorl of a dielectric-waveguide track as shows an outline configuration to drawing 4 with a perspective view as connection structure of the dielectric-

waveguide track of a laminating mold and a microstrip line is proposed.
[0009] As opposed to the dielectric-waveguide track 5 of the above-mentioned laminating mold which consists of side attachment walls 4 formed of the group penetration of the beer hall group arranged by two trains which according to drawing 4 whose dielectric substrates 1 are pinched by the initiative body whorl 2-3 of a pair, and connect between the initiative body whorls 2-3 further -- a conductor -- The slot hole 6 for electromagnetic couplings is formed in the initiative body whorl 2 of one of these, and by this, the line conductor 8 of a RF track and the dielectric-waveguide tracks 5, such as a microstrip line formed on the multilayer-interconnection substrate 7 grade, are combined electromagnetic, and it connects.
[0010] According to this connection structure, an electromagnetic coupling can be easily carried out to other line conductors for RFs by forming the slot hole 6 in a part of initiative body whorl 2. And the multilayer-interconnection substrate 7 and the dielectric-waveguide track 5 in which the line conductor 8 for RFs which has this connection structure was formed can all apply the conventional ceramic laminating technique, and can produce it easily.
[0011] However, with the connection structure of the dielectric-waveguide track 5 of such a laminating mold, and the line conductor 8 for RFs, since the laminating of the multilayer-interconnection substrate 7 with which the line conductor 8 for RFs was formed in the upper part of the dielectric-waveguide track 5 was carried out, the thickness of the whole connection will increase and there was a trouble that it was difficult to miniaturize the whole connection structure.
[0012] And since the characteristic impedance of the dielectric-waveguide track 5 and the line conductor 8 for RFs connected to the dielectric-waveguide track 5 through the slot hole 6 generally was not in agreement, in the connection, reflection of the RF signal by the inequality of a characteristic impedance occurred, and it had the trouble that a transparency property would also deteriorate in coincidence.
[0013] This invention is thought out in view of the trouble of the above-mentioned conventional technique, and the purpose is in offering the connection structure of the dielectric-waveguide track and the line conductor for RFs which can connect line conductors for RFs, such as a dielectric-waveguide track of a laminating mold, and other microstrip lines, the strip line, a RF track, in a good property even if both characteristic impedances differ.
[0014]
[Means for Solving the Problem] In the structure of connecting a dielectric-waveguide track and the line conductor for RFs as a result of this invention's repeating examination to the above-mentioned trouble the line conductor for RFs -- the edge of a dielectric-waveguide track -- inserting -- the penetration for connection from the insertion section -- with the structure where the thickness of a connection is thin, by connecting the edge of the line conductor for RFs to the initiative body whorl of a dielectric-waveguide track electrically with a conductor and the line conductor for connection, as the shape of a stairway is accomplished And it found out that the outstanding transparency property was acquired.
[0015] The connection structure of the dielectric-waveguide track of this invention, and the line conductor for RFs In the initiative body whorl of the pair which pinches a dielectric substrate from the upper and lower sides, and the transmission direction of a RF signal, at intervals of less than 1/2 repeat of signal wave length and the penetration for side attachment walls of two trains which connected between said initiative body whorls in said transmission direction and the direction which intersects perpendicularly electrically, and were formed in it by predetermined width of face -- a conductor -- with a group Provide the subconductor layer electrically connected with the group, and it changes. it forms in an initiative body whorl and parallel between said initiative body whorls -- having -- said penetration for side attachment walls -- a conductor -- said initiative body whorl and the penetration for side attachment walls -- a conductor, while inserting the edge of the line conductor for RFs which transmits said RF signal to the opening edge of the dielectric-waveguide track which transmits a RF signal by the field surrounded by the group and the subconductor layer The line conductor for connection arranged in parallel in the same transmission direction as said line conductor for RFs in the edge of this line conductor for RFs, and one side of said initiative body whorl, the penetration for connection arranged in the edge of this line conductor for connection by intersecting perpendicularly -- it is characterized by connecting electrically so that the shape of a

stairway may be accomplished with a conductor.
[0016]
[Embodiment of the Invention] Hereafter, it explains, referring to a drawing about the connection structure of the dielectric-waveguide track of this invention, and the line conductor for RFs.
[0017] Drawing 1 is the partial fracture perspective view showing an example of the gestalt of operation of the connection structure of the dielectric-waveguide track of this invention, and the line conductor for RFs.
[0018] the penetration for side attachment walls of two trains in which the initiative body whorl of the pair to which 11 pinches a dielectric substrate and 12 and 13 pinch the dielectric substrate 11 from the upper and lower sides, and 14 were less than 1/2 repeat spacing of signal wave length, and they were formed in it by predetermined width of face in drawing 1 in the direction of a signal transmission, and the direction which intersects perpendicularly as they connected between the initiative body whorls 12.13 of a pair in the direction of a signal transmission electrically -- a conductor -- it is a group. 15 [ moreover, ] -- the penetration for side attachment walls -- a conductor -- the penetration which forms each train of a group 14 -- a conductor -- it is the subconductor layer which connects comrades electrically and which was formed in parallel with the initiative body whorl 12-13. these initiative body whorl 12-13 and the penetration for side attachment walls -- a conductor -- the field surrounded by the group 14 and the subconductor layer 15 constitutes the dielectric-waveguide track 16 which transmits a RF signal.
[0019] On the other hand, 20 is line conductors for RFs, such as a microstrip line, and the strip line, a RF track, is formed the dielectric substrate top which is not illustrated and in a multilayer-interconnection substrate, and is connected with the dielectric-waveguide track 16. The dielectric substrate, multilayer-interconnection substrate, etc. may make the part share with some dielectric substrates 11 of the dielectric-waveguide track 16.
[0020] A conductor and 18 are the line conductors for connection, and the line conductor 18 for connection is arranged in parallel in the same transmission direction as the line conductor 20 for RFs. 17 [ and ] -- the penetration for connection -- The shape of a stairway is accomplished with a conductor 17 and the line conductor 18 for connection. the penetration for connection -- a conductor 17 intersects perpendicularly and is arranged in the edge of the line conductor 18 for connection -- having -- **** -- the penetration for these connection -- The edge of the line conductor 20 for RFs inserted in the opening edge of the dielectric-waveguide track 16 and one initiative body whorl 12 of the dielectric-waveguide track 16 are connected electrically.
[0021] moreover, the penetration for connection of this connection part -- the stair-like converter 19 consists of a conductor 17 and a line conductor 18 for connection. Since a converter 19 functions as an impedance converter which performs both characteristic-impedance adjustment when this will constitute the so-called ridge waveguide which narrowed spacing between the up-and-down initiative body whorls 12.13 in the dielectric-waveguide track 16 of a connection stair-like and the characteristic impedances of the dielectric-waveguide track 16 and the line conductor 20 for RFs differ, the reflection loss of the RF signal in a connection is reduced, and it becomes the connection structure of a good transparency property.
[0022] namely, the edge of the line conductor 20 for RFs which the edge of the line conductor 20 for RFs is inserted in the interior from the opening edge of the dielectric-waveguide track 16, and was inserted -- the penetration for connection -- it works as a ridge waveguide with the stair-like transducer 19 constituted by the conductor 17 and the line conductor 18 for connection, and the operation which reduces reflection of a RF signal is made. the thickness of the dielectric substrate with which the characteristic-impedance adjustment for connecting the dielectric-waveguide track 16 and the line conductor 20 for RFs with which characteristic impedances differ using such a converter 19 in the condition of low reflection constitutes a converter 19, and the penetration for connection -- it can adjust by the die length of a conductor 17 and the line conductor 18 for connection etc.
[0023] Although the dielectric-waveguide track 16 is constituted as a thing of a three-tiered structure and the line conductor 18 for connection is formed with the line conductor of one layer in the dielectric substrate 11 in the example of drawing 1 , it is also possible by considering the dielectric substrate 11 as a multilayer configuration more to increase the number of stages of a transducer 19 with two step, three step, four step, and five step --. Thus, if the number of stages of a transducer 19

is increased, matching of an impedance can be taken more effectively.
[0024] moreover, the penetration for connection -- since the leakage of a conductor 17 of an electromagnetic wave will be lost if the spacing is made smaller than 1/2 of signal wave length -- the penetration for connection -- a conductor -- as for spacing of 17 comrades, it is desirable that it is less than [ of signal wave length ] 1/2. the penetration for connection -- although the conductor 17 was arranged in one train in the example of drawing 1 , they may be two or more trains. Moreover, you may arrange in the shape of [ so-called ] alternate.
[0025] In addition, in drawing 1 , on account of a display, although the dielectric substrate 11 is omitted and being illustrated, such structures are usually formed into the dielectric substrate 11. Moreover, a part of initiative body whorl 12 is fractured and shown so that the structure inside the dielectric-waveguide track 16 may be known.
[0026] As shown in drawing 1 , the initiative body whorl 12-13 of a pair is formed in the location which pinches the dielectric substrate 11 of predetermined thickness C, and the initiative body whorl 12-13 is formed in the vertical side of the dielectric substrate 11 which faces across a transmission-line formation location at least. moreover, the through hole which connects the initiative body whorls 12 and 13 electrically between the initiative body whorls 12.13 -- a conductor and beer -- penetration of a conductor etc. -- many conductors prepare -- having -- penetration of these large number -- a conductor -- the penetration for side attachment walls of two trains -- a conductor -- the group 14 is formed.
[0027] the penetration for side attachment walls of two trains -- a conductor -- in the transmission direction, i.e., track formation direction, of a RF signal, a group 14 is less than (desirably below a quadrant) 1/2 predetermined repeat spacing (pitch) B of signal wave length, and is formed in the transmission direction and the direction which intersects perpendicularly with the predetermined spacing (width of face) A. This forms the electric side attachment wall in this dielectric-waveguide track 16.
[0028] the case where it uses by the single mode although there is especially no limit to the spacing C between the thickness 12.13 of the dielectric substrate 11, i.e., the initiative body whorl of a pair, here -- the penetration for side attachment walls -- a conductor -- it is good to consider as about 1/2 and about 2 times to the width of face A of a group 14. the part to which the part which hits the H plane of a dielectric waveguide 16 in the example of drawing 1 is equivalent to the Eth page in the initiative body whorl 12-13 -- the penetration for side attachment walls -- a conductor -- it is formed by the group 14 and the subconductor layer 15, respectively. moreover, the penetration for side attachment walls -- a conductor -- the part to which the part which is equivalent to the Eth page of about 2 times, then the dielectric-waveguide track 16 about the thickness of the dielectric substrate 11 to the width of face B of a group 14 hits an H plane in the initiative body whorl 12-13 -- the penetration for side attachment walls -- a conductor -- it will be formed by the group 14 and the subconductor layer 15, respectively.
[0029] moreover, penetration -- the repeat spacing B of a conductor is set as less than 1/2 spacing of signal wave length -- the penetration for side attachment walls -- a conductor -- an electric wall can be formed by the group 14. This spacing B is below the quadrant of signal wave length desirably.
[0030] Since a TEM wave can be spread between the initiative body whorls 12.13 of the pair arranged in parallel, the penetration for side attachment walls -- a conductor -- the penetration in each train of a group 14, since the clearance will act as a slot and an electromagnetic wave will leak, if the repeat spacing B of a conductor is larger than 1 (lambda/2)/2 of the signal wave length lambda even if it supplies electric power to this dielectric-waveguide track 16 in an electromagnetic wave -- an electromagnetic wave -- the penetration for side attachment walls -- a conductor -- it leaks from between groups 14 and does not spread along the false waveguide track made here. However, if the spacing B is smaller than lambda/2, an electric side attachment wall will be formed, and an electromagnetic wave cannot be perpendicularly spread to the dielectric-waveguide track 16, but it will be spread in the direction of a signal transmission of the dielectric-waveguide track 16, reflecting. consequently -- according to a configuration like drawing 1 -- the penetration for side attachment walls of the initiative body whorl 12-13 of a pair, and two trains -- a conductor -- the field of the size of AxC serves as [ the cross section surrounded by a group 14 and the subconductor layer 16 ] the dielectric-waveguide track 16.

[0031] in addition -- the example shown in drawing 1 -- the penetration for side attachment walls -- a conductor -- although the group 14 was formed in two trains -- this penetration for side attachment walls -- a conductor -- a group 14 -- four trains or six trains -- arranging -- the penetration for side attachment walls -- a conductor -- the false conductor by the group 14 -- forming a wall in three-fold [ a duplex and ] -- a conductor -- the leakage of the electromagnetic wave from a wall can also be prevented more effectively.
[0032] Since it becomes the transmission line by the dielectric waveguide according to such a dielectric-waveguide track 16, it is epsilonr about the specific inductive capacity of the dielectric substrate 11. If it carries out, the waveguide size is 1/rootepsilonr of the usual waveguide. It becomes magnitude. Therefore, specific-inductive-capacity epsilonr of the ingredient which constitutes the dielectric substrate 11 Waveguide size can be made small, and the miniaturization of a RF circuit can be attained and it can consider as the dielectric-waveguide track 16 of magnitude available also as the transmission line of the multilayer-interconnection substrate with which wiring is formed in high density, the package for semiconductor device receipt, or the radar between vehicles, so that it considers as a large thing.
[0033] in addition, the penetration for side attachment walls -- a conductor -- the penetration which constitutes a group 14 -- in order to realize a good transmission characteristic, as for this repeat spacing, considering as fixed repeat spacing is desirable [ the conductor is arranged as mentioned above at intervals of less than 1/2 repeat of signal wave length, and ], but as long as it is less than 1/2 spacing of signal wave length, it may be made to change suitably or some values may be combined.
[0034] Although it does not divide and limit if it has the property which functions as a dielectric and does not bar transmission of a RF signal as a dielectric substrate 11 which constitutes such a dielectric-waveguide track 16, as for the dielectric substrate 11, from the point of the precision at the time of forming the transmission line, and the ease of manufacture, consisting of the ceramics is desirable.
[0035] Although the ceramics with specific inductive capacity various until now as such ceramics is known, in order to transmit a RF signal on the dielectric-waveguide track concerning this invention, it is desirable that they are paraelectrics. Generally this is because as for the ferroelectric ceramics dielectric loss becomes and transmission loss becomes large in a RF field. Therefore, specific-inductive-capacity epsilonr of the dielectric substrate 11 4-100 Extent is suitable.
[0036] Moreover, for the line breadth of the wiring layer generally formed in a multilayer-interconnection substrate, or the package for semiconductor device receipt or the radar between vehicles, specific inductive capacity since it be about 1mm at the maximum be 100. When it use so that the upper part may become the electromagnetic-field distribution which an H plane, i.e., a field, roll in parallel with an upper field using an ingredient, the minimum frequency which can be used be computed with 15GHz, and become available also in the field of a microwave band.
[0037] The dielectric which consists of resin generally used as a dielectric substrate 11 on the other hand is specific-inductive-capacity epsilonr. Since it is about two, it cannot use, unless it is more than about 100 GHz, when line breadth is 1mm.
[0038] Moreover, although there is much what has a very small dielectric dissipation factor in such paraelectrics ceramics like an alumina or a silica, all paraelectrics ceramics is not available. In the case of a dielectric-waveguide track, there is almost no loss by the conductor, and most loss at the time of a signal transmission is loss by the dielectric. The loss alpha by the dielectric (dB/m) is expressed as follows.
alpha=27.3xtandelta/[lambda/{1-(lambda/lambdac) 2} 1 / 2]
Inside of a formula, tandelta: Dielectric dissipation factor lambda of a dielectric : Wavelength lambdac in a dielectric : When it applies to the rectangular waveguide (WRJ series) configuration by which cutoff wave length standardization was carried out, it is {1-(lambda/lambdac) 2} 1/2 in an upper type. It is about 0.75.
[0039] Therefore, in order to carry out to below -100 dB/m that is the transmission loss with which practical use can be presented, it is required to choose a dielectric so that the following relation may be materialized.
f is the frequency (GHz) of the RF signal to be used among fxepsilon r 1 / 2 xtandelta<=0.8 type.
[0040] As such a dielectric substrate 11, there are alumina ceramics, alumimium nitride ceramic

crystallized glass, etc., for example. While the dielectric substrate 11 by these carries out addition mixing of the suitable organic solvent and solvent for example, for ceramic raw material powder and forms it slurry-like The ceramic green sheet of two or more sheets is obtained by adopting a well-known doctor blade method, the well-known calendering roll method, etc. conventionally, and making this with the shape of a sheet. While performing suitable punching processing for each of these ceramic green sheet after an appropriate time, the laminating of these is carried out. In the case of alumina ceramics, in the case of 1500-1700 degrees C and crystallized glass, it is manufactured by calcinating at the temperature of 1600-1900 degrees C in the case of 850-1000 degrees C and the alumimium nitride ceramics.

[0041] Moreover, the initiative body whorl 12-13, the subconductor layer 15, the line conductor 20 for RFs, and the line conductor 18 for connection of a pair for example, when the dielectric substrate 11 consists of alumina ceramics It prints on a ceramic green sheet so that the transmission line may be completely covered at least by thick film printing using what carried out addition mixing of oxides, an organic solvent, solvents, etc., such as a suitable alumina silica magnesia for metal powder, such as a tungsten, and was made into the shape of a paste. After an appropriate time, It calcinates at about 1600-degree C elevated temperature, and as it becomes the thickness of about 5-15 micrometers, it forms. In addition, in the case of crystallized glass, in the case of the alumimium nitride ceramics, as metal powder, tungsten molybdenum is suitable for copper, gold, and silver. Moreover, generally thickness of the initiative body whorl 12-13 and the subconductor layer 15 is set to about 5-50 micrometers.

[0042] moreover, the penetration for side attachment walls -- a conductor -- a group 14 and the penetration for connection -- the penetration which constitutes a conductor 17 -- a conductor -- for example, a beer hall -- a conductor and a through hole -- what is necessary is just to form with a conductor etc. The cross-section configuration may be polygons, such as a rectangle besides a round shape with easy manufacture, and a rhombus. these penetration -- the metal paste same to the through tube which pierced the conductor for example, to the ceramic green sheet, processed, and was produced as initiative body whorl 12.13 grade -- embedding -- after an appropriate time and dielectric substrate 11 grade -- simultaneously, it calcinates and forms. in addition, penetration -- a conductor -- diameters 50-300 mum is suitable.

[0043]

[Example] Next, the example of the connection structure of the dielectric-waveguide track of this invention and the line conductor for RFs is explained.

[0044] Drawing 2 is the perspective view showing the outline configuration of an example of the gestalt of operation of the connection structure of the dielectric-waveguide track of this invention, and the line conductor for RFs, the same sign is given to the same part as drawing 1 , and the dielectric substrate 11 has omitted the display. moreover, the penetration for side attachment walls for forming a side attachment wall, in order to make an understanding easy -- a conductor -- a side attachment wall equivalent about a group 14 and the subconductor layer 15 expresses, and the dielectric-waveguide track 16 is expressed as the profile.

[0045] In the case of this example, it is specific-inductive-capacity epsilonr to a dielectric substrate. 4.8 Track width of face of the microstrip line as 1.5 mmx0.6 mm and a line conductor 20 for RFs was set to 0.267 mm for the size of the cross section of the dielectric-waveguide track 16 using the ceramic ingredient. Moreover, the dielectric-waveguide track 16 carried out the four-sheet laminating of the dielectric substrate whose thickness is 0.15mm, and constituted it.

[0046] In this example, the upper part of a microstrip line is made into air, and 0.279 mm insertion is carried out at the opening edge of the edge dielectric-waveguide track 16 of that line conductor 20. a converter 19 -- 0.15mm spacing -- the line conductor 18 for connection -- two-layer formation -- carrying out -- between the edge of the edges of each line conductor 18, and the line conductor 20 for RFs, and the initiative body whorls 12 of the dielectric-waveguide track 16 -- the penetration for connection -- it connected electrically with the conductor 17. At this time, each set the line conductor 18 for connection of the 1st layer and a two-layer eye to width-of-face 0.267 mm and die-length 0.279 mm. moreover, the penetration for connection -- the conductor 17 was made into diameter 0.1 mm and die length of 0.15mm. the edge of the line conductor 20 for RFs inserted in the opening edge of the dielectric-waveguide track 16 by this -- two or more penetration for connection -- pass a

conductor 17 and two or more line conductors 18 for connection -- it connects with the initiative body whorl 12 of the dielectric-waveguide track 16 electrically.
[0047] And about the example of a comparison which did not prepare this example and transducer 19 (penetration for connection a conductor 17 and the line conductor 18 for connection), the reflection coefficient S11 of connection structure was measured with the network analyzer, and it asked for it. The result is shown in drawing 3 .
[0048] Drawing 3 is the diagram showing the frequency characteristics of the reflection coefficient S11 in connection structure with the line conductor for RFs of a dielectric-waveguide track, an axis of abscissa expresses a frequency (unit: GHz), an axis of ordinate expresses a reflection coefficient S11 (unit: dB), among the characteristic curves which show the frequency characteristics of a reflection coefficient S11, A shows the property of the example of a comparison and B shows the property of the example of this invention.
[0049] according to [ the result of the connection structure of this invention ] B to the reflection coefficient S11 having consisted of a result of drawing 3 only by about -6dB in A as a result of the example of a comparison without a transducer -- the penetration for connection -- by preparing the transducer which consists of a conductor and the line conductor for connection shows that the good property of -20dB or less was acquired for the reflection coefficient S11. This shows that matching of the characteristic impedance of a dielectric-waveguide track and the line conductor for high frequency is performed by the transducer (penetration for connection a conductor and the line conductor for connection) concerning the connection structure of this invention.
[0050]
[Effect of the Invention] According to the connection structure of the dielectric-waveguide track of this invention, and the line conductor for RFs, as explained in full detail above The line conductor for connection which inserted the edge of the line conductor for RFs in the opening edge of a dielectric-waveguide track, and was arranged in parallel in the same transmission direction as the line conductor for RFs in the edge and one of the initiative body whorl of a dielectric-waveguide track of these, the penetration for connection arranged in the edge of this line conductor for connection by intersecting perpendicularly -- from having connected electrically so that the shape of a stairway might be accomplished with a conductor A miniaturization can be attained by the ability making thickness of a connection into thin structure, and, moreover, the reflection loss of the RF signal in a connection can acquire the small excellent transparency property. Furthermore, even if it is the case where the characteristic impedances of a dielectric-waveguide track and the line conductor for RFs differ, matching of a characteristic impedance can be taken and it can be made to connect in a good property.
[0051] And since the connection structure of the dielectric-waveguide track of this invention and the line conductor for RFs is easily producible with sheet lamination techniques, such as a green sheet laminated layers method, productivity can manufacture it cheaply highly.
[0052] According to this invention, by the above, the connection structure of the dielectric-waveguide track and the line conductor for RFs which can connect line conductors for RFs, such as a dielectric-waveguide track of a laminating mold, and other microstrip lines, the strip line, a RF track, in a good property even if both characteristic impedances differ was able to be offered.

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DRAWINGS

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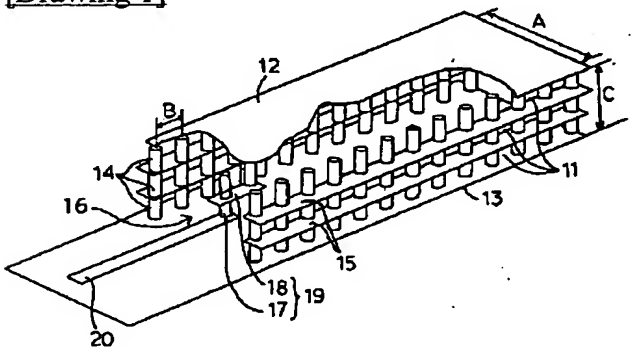
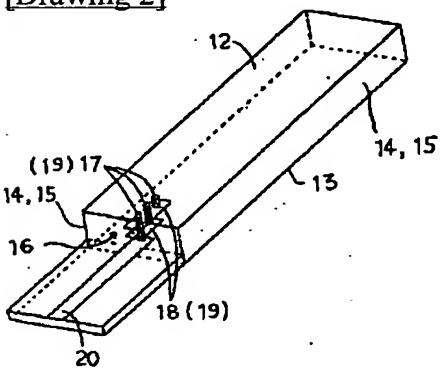
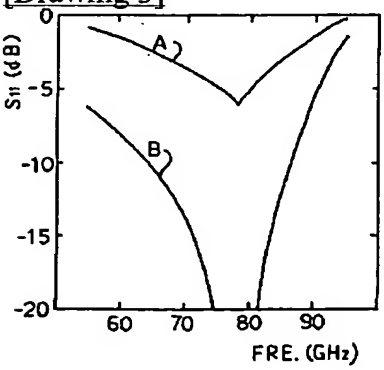
[Drawing 1]



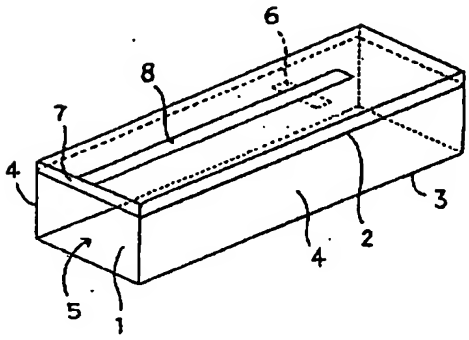

[Drawing 2]




[Drawing 3]




[Drawing 4]

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# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-216605
(43)Date of publication of application : 04.08.2000

(51)Int.Cl. H01P 5/107
H05K 1/02

(21)Application number : 11-013004
(22)Date of filing : 21.01.1999

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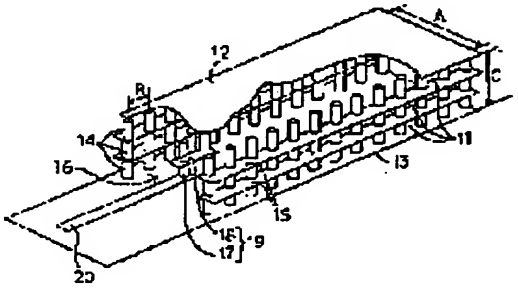
UCHIMURA HIROSHI

## (54) CONNECTION STRUCTURE BETWEEN DIELECTRIC WAVEGUIDE LINE AND HIGH FREQUENCY LINE CONDUCTOR

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a connection structure between a dielectric waveguide line and a high frequency line conductor that can connect the laminated dielectric waveguide line with the high frequency line conductor such as a microstrip line, a strip line or a high frequency line with an excellent characteristic even when a characteristic impedance of the dielectric waveguide line differs from that of the high frequency line conductor.




SOLUTION: The connection structure is used to connect a high frequency line conductor 20 with a dielectric waveguide line 16 by inserting an end of the high frequency line conductor 20 to an opening end of the dielectric waveguide line 16 consisting of a couple of main conductor layers 12, 13 having a dielectric board 11 inbetween and two rows of through-conductor groups 14 for sidewall that are formed between the main conductor layers 12, 13 at a prescribed interval with a prescribed width and of a sub conductor layer 15 and by electrically connecting the end of the high frequency line conductor 20 and one (12) of the main conductor layers 12, 13 with a connection use line conductor 18 and a connection use through-conductor 17 in a way of forming a step. Even when the characteristic impedance of the conductor 20 differs from that of the line 16, the connection structure connects the both with an excellent characteristic and since the thickness of the connection structure is thin, the connection structure can be miniaturized.

LEGAL STATUS

[Date of request for examination] 26.08.2002

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number] 3517143

[Date of registration] 30.01.2004

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

(19)日本国特許庁(JP)　(12)公開特許公報（A）　(11)特許出願公開番号

特開２０００－２１６６０５
（Ｐ２０００－２１６６０５Ａ）
(43)公開日　平成12年8月4日(2000.8.4)

| (51)Int.Cl.' | 識別記号 | FI | | テーマコード(参考) |
|---|---|---|---|---|
| Ｈ０１Ｐ | 5/107 | Ｈ０１Ｐ | 5/107 | Ｅ　5E338 |
| | | | | Ｇ |
| Ｈ０５Ｋ | 1/02 | Ｈ０５Ｋ | 1/02 | Ｐ |

審査請求　未請求　請求項の数１　ＯＬ　（全７頁）

(21)出願番号　特願平11-13004

(22)出願日　平成11年1月21日(1999.1.21)

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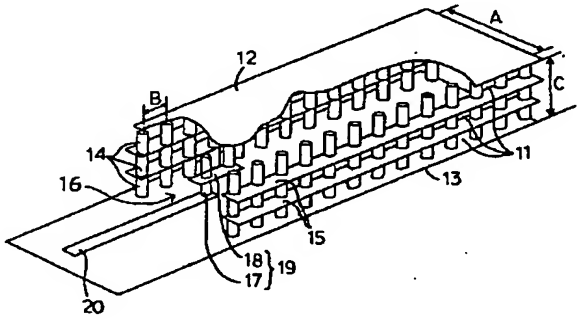
Ｆターム(参考)　5E338 AA03 BB02 BB16 BB25 CC02 CC05 CD02 CD11 CD32 EE13 EE22

(54)【発明の名称】誘電体導波管線路と高周波用線路導体との接続構造

(57)【要約】

【課題】　誘電体導波管線路と高周波用線路導体との接続をコンパクトな構造でもって良好な特性で行なうことが困難であった。

【解決手段】　誘電体基板11を挟持する一対の主導体層12・13と、所定の繰り返し間隔で、かつ所定の幅で主導体層12・13間に形成された２列の側壁用貫通導体群14と、副導体層15とを具備して成る誘電体導波管線路16の開口端に、高周波用線路導体20の端部を挿入するとともに、その端部と一方の主導体層12とを、接続用線路導体18と接続用貫通導体17とにより階段状を成すように電気的に接続した誘電体導波管線路16と高周波用線路導体20との接続構造である。両者の特性インピーダンスが異なるものであっても良好な特性で接続することができ、接続部の厚みが薄いので小型化を図ることもできる。



1

【特許請求の範囲】

【請求項１】　誘電体基板を上下から挟持する一対の主導体層と、高周波信号の伝送方向に信号波長の２分の１未満の繰り返し間隔で、かつ前記伝送方向と直交する方向に所定の幅で前記主導体層間を電気的に接続して形成された２列の側壁用貫通導体群と、前記主導体層間に主導体層と平行に形成され、前記側壁用貫通導体群と電気的に接続された副導体層とを具備して成り、前記主導体層、側壁用貫通導体群および副導体層に囲まれた領域によって高周波信号を伝送する誘電体導波管線路の開口端に、前記高周波信号を伝送する高周波用線路導体の端部を挿入するとともに、該高周波用線路導体の端部と前記主導体層の一方とを、前記高周波用線路導体と同じ伝送方向で平行に配設された接続用線路導体と、該接続用線路導体の端部に直交して配設された接続用貫通導体とにより階段状を成すように電気的に接続したことを特徴とする誘電体導波管線路と高周波用線路導体との接続構造。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、マイクロ波帯やミリ波帯等の高周波信号を伝送する伝送線路である誘電体導波管線路と、マイクロストリップ線路等の高周波用線路導体とを低損失で接続できる、誘電体導波管線路と高周波用線路導体との接続構造に関するものである。

【０００２】

【従来の技術】近年、マイクロ波帯やミリ波帯等の高周波信号を用いた移動体通信および車間レーダ等の研究が盛んに進められている。これらの高周波回路において高周波信号を伝送するための高周波用伝送線路としては、従来より、同軸線路や導波管・誘電体導波管線路・マイクロストリップ線路やストリップ線路等の高周波用線路導体などが知られている。

【０００３】最近では、高周波回路を構成する配線回路内には種類の異なる高周波線路が複数配置されるために、これら高周波線路相互間の接続技術が重要となっており、その接続構造について様々な構造が提案されている。

【０００４】例えば、導波管または誘電体導波管と同軸線路との接続構造では、同軸線路の信号線を導波管内に挿入して高周波的に結合することによって接続される。

【０００５】また、導波管とマイクロストリップ線路との接続構造では、導波管とマイクロストリップ線路とを直交させて接続する場合には、マイクロストリップ線路が形成された誘電体基板を導波管内に挿入する構造が用いられる。また、導波管とマイクロストリップ線路とを平行な方向で接続する場合には、マイクロストリップ線路の線路導体を、接続する端部へ向かって曲線状に狭くしたいわゆるリッジ導波管の内部に挿入する構造が知られている。

2

【０００６】

【発明が解決しようとする課題】最近に至り、高周波線路を高周波回路が構成される基板上または基板内に形成すると小型化の点で有利となることから、多層構造の配線基板内に誘電体導波管線路を積層技術によって形成することが望まれるようになっている。例えば、特開平６－53711 号においては、誘電体基板を一対の主導体層で挟み、さらに導体層間を接続する２列に配設されたビアホール群によって側壁を形成した導波管線路が提案されている。この導波管線路は、誘電体材料の四方を一対の主導体層とビアホール群による擬似的な導体壁で囲むことによって導体壁内の領域を信号伝送用の線路としたものである。

【０００７】このような多層配線基板の内部に配設される積層型の誘電体導波管線路を、主にマイクロ波およびミリ波用のセラミック多層配線基板あるいは高周波用半導体パッケージの伝送線路として用いる上では、他の高周波回路との接続が必要になる。

【０００８】これに対し、積層型の誘電体導波管線路とマイクロストリップ線路との接続構造としては、図４に斜視図で概略構成を示すような、誘電体導波管線路の主導体層に設けたスロット孔による電磁的な結合を用いた接続構造が提案されている。

【０００９】図４によれば、誘電体基板１を一対の主導体層２・３で挟み、さらに主導体層２・３間を接続する２列に配設されたビアホール群等の貫通導体群によって形成された側壁４とで構成される前述の積層型の誘電体導波管線路５に対し、その一方の主導体層２に電磁結合用のスロット孔６を形成し、これによって、多層配線基板７等の上に形成されたマイクロストリップ線路等の高周波線路の線路導体８と誘電体導波管線路５とを電磁的に結合して接続するものである。

【００１０】この接続構造によれば、主導体層２の一部にスロット孔６を形成することにより容易に他の高周波用線路導体と電磁結合することができる。しかも、かかる接続構造を有する高周波用線路導体８を形成した多層配線基板７ならびに誘電体導波管線路５は、いずれも従来のセラミック積層技術を応用して容易に作製することができる。

【００１１】しかしながら、このような積層型の誘電体導波管線路５と高周波用線路導体８との接続構造では、誘電体導波管線路５の上部に高周波用線路導体８が形成された多層配線基板７を積層しているため、接続部全体の厚みが増すこととなってしまい、接続構造全体を小型化することが困難であるという問題点があった。

【００１２】しかも、誘電体導波管線路５と、スロット孔６を介して誘電体導波管線路５に接続される高周波用線路導体８との特性インピーダンスは一般には一致しないため、接続部において特性インピーダンスの不一致による高周波信号の反射が発生し、同時に透過特性も劣化

することとなるという問題点があった。

【００１３】本発明は上記従来技術の問題点に鑑みて案出されたものであり、その目的は、積層型の誘電体導波管線路と、他のマイクロストリップ線路やストリップ線路・高周波線路等の高周波用線路導体とを、両者の特性インピーダンスが異なるものであっても良好な特性で接続することができる誘電体導波管線路と高周波用線路導体との接続構造を提供することにある。

【００１４】

【課題を解決するための手段】本発明は、上記の問題点に対して検討を重ねた結果、誘電体導波管線路と高周波用線路導体とを接続する構造において、高周波用線路導体を誘電体導波管線路の端部に挿入し、その挿入部から接続用貫通導体と接続用線路導体とによって階段状を成すようにして高周波用線路導体の端部を誘電体導波管線路の主導体層に電気的に接続することにより、接続部の厚みが薄い構造で、しかも優れた透過特性が得られることを見出した。

【００１５】本発明の誘電体導波管線路と高周波用線路導体との接続構造は、誘電体基板を上下から挟持する一対の主導体層と、高周波信号の伝送方向に信号波長の２分の１未満の繰り返し間隔で、かつ前記伝送方向と直交する方向に所定の幅で前記主導体層間を電気的に接続して形成された２列の側壁用貫通導体群と、前記主導体層間に主導体層と平行に形成され、前記側壁用貫通導体群と電気的に接続された副導体層とを具備して成り、前記主導体層、側壁用貫通導体群および副導体層に囲まれた領域によって高周波信号を伝送する誘電体導波管線路の開口端に、前記高周波信号を伝送する高周波用線路導体の端部を挿入するとともに、この高周波用線路導体の端部と前記主導体層の一方とを、前記高周波用線路導体と同じ伝送方向で平行に配設された接続用線路導体と、この接続用線路導体の端部に直交して配設された接続用貫通導体とにより階段状を成すように電気的に接続したことを特徴とするものである。

【００１６】

【発明の実施の形態】以下、本発明の誘電体導波管線路と高周波用線路導体との接続構造について図面を参照しながら説明する。

【００１７】図１は、本発明の誘電体導波管線路と高周波用線路導体との接続構造の実施の形態の一例を示す部分破断斜視図である。

【００１８】図１において、11は誘電体基板、12および13は誘電体基板11を上下から挟持する一対の主導体層、14は信号伝送方向に信号波長の２分の１未満の繰り返し間隔で、かつ信号伝送方向と直交する方向に所定の幅で一対の主導体層12・13間を電気的に接続するようにして形成された２列の側壁用貫通導体群である。また、15は側壁用貫通導体群14の各列を形成する貫通導体同士を電気的に接続する、主導体層12・13と平行に形成された副導体層である。これら主導体層12・13と側壁用貫通導体群14および副導体層15に囲まれた領域によって、高周波信号を伝送する誘電体導波管線路16を構成する。

【００１９】一方、20はマイクロストリップ線路やストリップ線路・高周波線路等の高周波用線路導体であり、図示しない誘電体基板上や多層配線基板内に形成されて誘電体導波管線路16と接続される。その誘電体基板や多層配線基板等は、その一部を誘電体導波管線路16の誘電体基板11の一部と共有させてもよい。

【００２０】そして、17は接続用貫通導体、18は接続用線路導体であり、接続用線路導体18は高周波用線路導体20と同じ伝送方向で平行に配設され、接続用貫通導体17は接続用線路導体18の端部に直交して配設されており、これら接続用貫通導体17と接続用線路導体18とによって階段状を成すようにして、誘電体導波管線路16の開口端に挿入した高周波用線路導体20の端部と誘電体導波管線路16の一方の主導体層12とを電気的に接続している。

【００２１】また、この接続部分の接続用貫通導体17と接続用線路導体18とで階段状の変換器19を構成している。これにより、接続部の誘電体導波管線路16において上下の主導体層12・13間の間隔を狭くしたいわゆるリッジ導波管を階段状に構成することとなり、誘電体導波管線路16と高周波用線路導体20との特性インピーダンスが異なる場合に、変換器19が両者の特性インピーダンス整合を行なうインピーダンス変換器として機能するため、接続部における高周波信号の反射損失を低減し、良好な透過特性の接続構造となる。

【００２２】すなわち、高周波用線路導体20の端部は誘電体導波管線路16の開口端からその内部に挿入されており、挿入された高周波用線路導体20の端部は、接続用貫通導体17および接続用線路導体18によって構成された階段状の変換器19とともにリッジ導波管として働き、高周波信号の反射を低減させる作用をなす。このような変換器19を用いて特性インピーダンスの異なる誘電体導波管線路16と高周波用線路導体20とを低反射の状態で接続させるための特性インピーダンス調整は、変換器19を構成する誘電体基板の厚みや、接続用貫通導体17および接続用線路導体18の長さ等で調整可能である。

【００２３】図１の例では、誘電体基板11を３層構造のものとして誘電体導波管線路16を構成し、接続用線路導体18は１層の線路導体で形成されているが、誘電体基板11をより多層構成とすることにより、変換部19の段数を２段・３段・４段・５段…と増すことも可能である。このように変換部19の段数を増すと、より効果的にインピーダンスのマッチングをとることができる。

【００２４】また、接続用貫通導体17は、その間隔を信号波長の２分の１より小さくしていくと電磁波の漏れはなくなるため、接続用貫通導体17同士の間隔は信号波長の２分の１未満であることが望ましい。接続用貫通導体17は図１の例では１列に配設したが、複数列であっても

良い。また、いわゆる千鳥状に配置しても良い。

【００２５】なお、図１においては、表示の都合上、誘電体基板11は省略して図示しているが、これらの構造は通常は誘電体基板11中に形成されるものである。また、誘電体導波管線路16の内部の構造が分かるように、主導体層12の一部は破断して示している。

【００２６】図１に示すように、所定の厚みＣの誘電体基板11を挟持する位置に一対の主導体層12・13が形成されており、主導体層12・13は誘電体基板11の少なくとも伝送線路形成位置を挟む上下面に形成されている。また、主導体層12・13間には主導体層12と13とを電気的に接続するスルーホール導体やビア導体等の貫通導体が多数設けられ、これら多数の貫通導体により２列の側壁用貫通導体群14を形成している。

【００２７】２列の側壁用貫通導体群14は、高周波信号の伝送方向すなわち線路形成方向に信号波長の２分の１未満（望ましくは４分の１以下）の所定の繰り返し間隔（ピッチ）Ｂで、かつ伝送方向と直交する方向に所定の間隔（幅）Ａをもって形成されている。これにより、この誘電体導波管線路16における電気的な側壁を形成している。

【００２８】ここで、誘電体基板11の厚みすなわち一対の主導体層12・13間の間隔Ｃに対する制限は特にないが、シングルモードで用いる場合には側壁用貫通導体群14の幅Ａに対して２分の１程度または２倍程度とすることがよい。図１の例では誘電体導波管16のＨ面に当たる部分が主導体層12・13で、Ｅ面に当たる部分が側壁用貫通導体群14および副導体層15でそれぞれ形成される。また、側壁用貫通導体群14の幅Ｂに対して誘電体基板11の厚みを２倍程度とすれば、誘電体導波管線路16のＥ面に当たる部分が主導体層12・13で、Ｈ面に当たる部分が側壁用貫通導体群14および副導体層15でそれぞれ形成されることとなる。

【００２９】また、貫通導体の繰り返し間隔Ｂが信号波長の２分の１未満の間隔に設定されることで、側壁用貫通導体群14により電気的な壁が形成できる。この間隔Ｂは、望ましくは信号波長の４分の１以下である。

【００３０】平行に配置された一対の主導体層12・13間にはＴＥＭ波が伝播できるため、側壁用貫通導体群14の各列における貫通導体の繰り返し間隔Ｂが信号波長λの２分の１（λ／２）よりも大きいと、その隙間がスロットとして作用して電磁波が漏れるので、この誘電体導波管線路16に電磁波を給電しても電磁波は側壁用貫通導体群14の間から漏れてしまい、ここで作られる疑似的な導波管線路に沿って伝播しない。しかし、その間隔Ｂがλ／２より小さいと、電気的な側壁を形成することとなって電磁波は誘電体導波管線路16に対して垂直方向に伝播することができず、反射しながら誘電体導波管線路16の信号伝送方向に伝播される。その結果、図１のような構成によれば、一対の主導体層12・13と２列の側壁用貫通導体群14および副導体層16とによって囲まれる断面積がＡ×Ｃのサイズの領域が誘電体導波管線路16となる。

【００３１】なお、図１に示した例では側壁用貫通導体群14は２列に形成したが、この側壁用貫通導体群14を４列あるいは６列に配設して、側壁用貫通導体群14による疑似的な導体壁を２重・３重に形成することにより、導体壁からの電磁波の漏れをより効果的に防止することもできる。

【００３２】このような誘電体導波管線路16によれば、誘電体導波管による伝送線路となるので、誘電体基板11の比誘電率を$\varepsilon_r$とするとその導波管サイズは通常の導波管の$1/\sqrt{\varepsilon_r}$の大きさになる。従って、誘電体基板11を構成する材料の比誘電率$\varepsilon_r$を大きいものとするほど導波管サイズを小さくすることができて高周波回路の小型化を図ることができ、高密度に配線が形成される多層配線基板または半導体素子収納用パッケージあるいは車間レーダの伝送線路としても利用可能な大きさの誘電体導波管線路16とすることができる。

【００３３】なお、側壁用貫通導体群14を構成する貫通導体は前述のように信号波長の２分の１未満の繰り返し間隔で配設されており、この繰り返し間隔は良好な伝送特性を実現するためには一定の繰り返し間隔とすることが望ましいが、信号波長の２分の１未満の間隔であれば、適宜変化させたりいくつかの値を組み合わせたりしてもよい。

【００３４】このような誘電体導波管線路16を構成する誘電体基板11としては、誘電体として機能し高周波信号の伝送を妨げることのない特性を有するものであればとりわけ限定するものではないが、伝送線路を形成する際の精度および製造の容易性の点からは、誘電体基板11はセラミックスから成ることが望ましい。

【００３５】このようなセラミックスとしてはこれまで様々な比誘電率を持つセラミックスが知られているが、本発明に係る誘電体導波管線路によって高周波信号を伝送するためには常誘電体であることが望ましい。これは、一般に強誘電体セラミックスは高周波領域では誘電損失が大きく伝送損失が大きくなるためである。従って、誘電体基板11の比誘電率$\varepsilon_r$は４～100 程度が適当である。

【００３６】また、一般に多層配線基板や半導体素子収納用パッケージあるいは車間レーダに形成される配線層の線幅は最大でも１mm程度であることから、比誘電率が100 の材料を用い、上部がＨ面すなわち磁界が上側の面に平行に巻く電磁界分布になるように用いた場合は、用いることのできる最小の周波数は15ＧＨｚと算出され、マイクロ波帯の領域でも利用可能となる。

【００３７】一方、一般的に誘電体基板11として用いられる樹脂からなる誘電体は、比誘電率$\varepsilon_r$が２程度であるため、線幅が１mmの場合は約100 ＧＨｚ以上でないと利用することができないものとなる。

【００３８】また、このような常誘電体セラミックスの中にはアルミナやシリカ等のように誘電正接が非常に小さなものが多いが、全ての常誘電体セラミックスが利用可能であるわけではない。誘電体導波管線路の場合は導体による損失はほとんどなく、信号伝送時の損失のほとんどは誘電体による損失である。その誘電体による損失α（ｄＢ／ｍ）は次のように表わされる。

$\alpha = 27.3 \times \tan\delta / [\lambda / \{1 - (\lambda/\lambda c)^2\}^{1/2}]$

式中、$\tan\delta$：誘電体の誘電正接

$\lambda$　：誘電体中の波長

$\lambda c$　：遮断波長

規格化された矩形導波管（ＷＲＪシリーズ）形状に準ずると、上式中の$\{1 - (\lambda/\lambda c)^2\}^{1/2}$は0.75程度である。

【００３９】従って、実用に供し得る伝送損失である－100 ｄＢ／ｍ以下にするには、次の関係が成立するように誘電体を選択することが必要である。

$f \times \varepsilon_r^{1/2} \times \tan\delta \leqq 0.8$

式中、ｆは使用する高周波信号の周波数（ＧＨｚ）である。

【００４０】このような誘電体基板11としては、例えばアルミナセラミックスや窒化アルミニウムセラミックス・ガラスセラミックス等がある。これらによる誘電体基板11は、例えばセラミックス原料粉末に適当な有機溶剤・溶媒を添加混合して泥漿状になすとともに、これを従来周知のドクターブレード法やカレンダーロール法等を採用してシート状となすことによって複数枚のセラミックグリーンシートを得て、しかる後、これらセラミックグリーンシートの各々に適当な打ち抜き加工を施すとともにこれらを積層し、アルミナセラミックスの場合は1500～1700℃、ガラスセラミックスの場合は850 ～1000℃、窒化アルミニウムセラミックスの場合は1600～1900℃の温度で焼成することによって製作される。

【００４１】また、一対の主導体層12・13および副導体層15、ならびに高周波用線路導体20および接続用線路導体18は、例えば誘電体基板11がアルミナセラミックスから成る場合には、タングステン等の金属粉末に適当なアルミナ・シリカ・マグネシア等の酸化物や有機溶剤・溶媒等を添加混合してペースト状にしたものを用いて厚膜印刷法により少なくとも伝送線路を完全に覆うようにセラミックグリーンシート上に印刷し、しかる後、約1600℃の高温で焼成し、厚み５～15μｍ程度となるようにして形成する。なお、金属粉末としては、ガラスセラミックスの場合は銅・金・銀が、窒化アルミニウムセラミックスの場合はタングステン・モリブデンが好適である。また、主導体層12・13および副導体層15の厚みは一般的に５～５０μｍ程度とされる。

【００４２】また、側壁用貫通導体群１４ならびに接続用貫通導体17を構成する貫通導体は、例えばビアホール導体やスルーホール導体等により形成すればよい。その断面形状は製作が容易な円形の他、矩形や菱形等の多角形であってもよい。これら貫通導体は、例えばセラミックグリーンシートに打ち抜き加工を施して作製した貫通孔に主導体層12・13等と同様の金属ペーストを埋め込み、しかる後、誘電体基板11等と同時に焼成して形成する。なお、貫通導体は直径50～300 μｍが適当である。

【００４３】

【実施例】次に、本発明の誘電体導波管線路と高周波用線路導体との接続構造の具体例について説明する。

【００４４】図２は本発明の誘電体導波管線路と高周波用線路導体との接続構造の実施の形態の一例の概略構成を示す斜視図であり、図１と同様の箇所には同じ符号を付してあり、誘電体基板11は表示を省略してある。また、理解を容易にするために側壁を形成するための側壁用貫通導体群14および副導体層15については等価的な側壁で表現し、誘電体導波管線路16は輪郭で表示している。

【００４５】この例の場合は、誘電体基板に比誘電率$\varepsilon_r$が4.8 のセラミックス材料を用い、誘電体導波管線路16の断面のサイズを1.５ ｍｍ×0.６ ｍｍ、高周波用線路導体20としてのマイクロストリップ線路の線路幅を0.267 ｍｍとした。また、誘電体導波管線路16は厚みが0.15 ｍｍの誘電体基板を４枚積層して構成した。

【００４６】この例ではマイクロストリップ線路の上部は空気とされ、その線路導体20の端部誘電体導波管線路16の開口端に0.279 ｍｍ挿入されている。変換器19は、0.15ｍｍ間隔で接続用線路導体18を２層形成し、各線路導体18の端部同士および高周波用線路導体20の端部ならびに誘電体導波管線路16の主導体層12との間を接続用貫通導体17で電気的に接続した。このとき、１層目および２層目の接続用線路導体18は、いずれも幅0.267 ｍｍ・長さ0.279 ｍｍとした。また、接続用貫通導体17は直径0.１ ｍｍ・長さ0.15ｍｍとした。これにより、誘電体導波管線路16の開口端に挿入された高周波用線路導体20の端部は、複数の接続用貫通導体17および複数の接続用線路導体18を経て誘電体導波管線路16の主導体層12と電気的に接続されている。

【００４７】そして、この例ならびに変換部19（接続用貫通導体17および接続用線路導体18）を設けなかった比較例につき、接続構造の反射係数$S_{11}$をネットワーク・アナライザにより測定して求めた。その結果を図３に示す。

【００４８】図３は誘電体導波管線路の高周波用線路導体との接続構造における反射係数$S_{11}$の周波数特性を示す線図であり、横軸は周波数（単位：ＧＨｚ）を、縦軸は反射係数$S_{11}$（単位：ｄＢ）を表わし、反射係数$S_{11}$の周波数特性を示す特性曲線のうちＡは比較例の特性を、Ｂは本発明の実施例の特性を示している。

【００４９】図３の結果より、変換部が無い比較例の結

果Ａにおいては反射係数$S_{11}$は－６ｄＢ程度までにしかならなかったのに対し、本発明の接続構造の結果Ｂによれば、接続用貫通導体および接続用線路導体から成る変換部を設けることにより、反射係数$S_{11}$が－20ｄＢ以下の良好な特性が得られたことが分かる。このことは、本発明の接続構造にかかる変換部（接続用貫通導体および接続用線路導体）により、誘電体導波管線路と高周波用線路導体との特性インピーダンスのマッチングが行なわれていることを示すものである。

【００５０】

【発明の効果】以上詳述した通り、本発明の誘電体導波管線路と高周波用線路導体との接続構造によれば、誘電体導波管線路の開口端に高周波用線路導体の端部を挿入し、その端部と誘電体導波管線路の主導体層の一方とを、高周波用線路導体と同じ伝送方向で平行に配設された接続用線路導体と、この接続用線路導体の端部に直交して配設された接続用貫通導体とにより階段状を成すように電気的に接続したことから、接続部の厚みを薄い構造とすることができて小型化を図ることができ、しかも、接続部における高周波信号の反射損失が小さく優れた透過特性を得ることができる。さらに、誘電体導波管線路と高周波用線路導体との特性インピーダンスが異なる場合であっても、特性インピーダンスのマッチングをとって良好な特性で接続させることができる。

【００５１】しかも、本発明の誘電体導波管線路と高周波用線路導体との接続構造は、グリーンシート積層法等のシート積層技術により容易に作製することができるので、生産性が高く安価に製造することができる。

【００５２】以上により、本発明によれば、積層型の誘電体導波管線路と、他のマイクロストリップ線路やストリップ線路・高周波線路等の高周波用線路導体とを、両者の特性インピーダンスが異なるものであっても良好な特性で接続することができる誘電体導波管線路と高周波用線路導体との接続構造を提供することができた。

【図面の簡単な説明】

【図１】本発明の誘電体導波管線路と高周波用線路導体との接続構造の実施の形態の一例を示す部分破断斜視図である。

【図２】本発明の誘電体導波管線路と高周波用線路導体との接続構造の実施の形態の一例の概略構成を示す斜視図である。

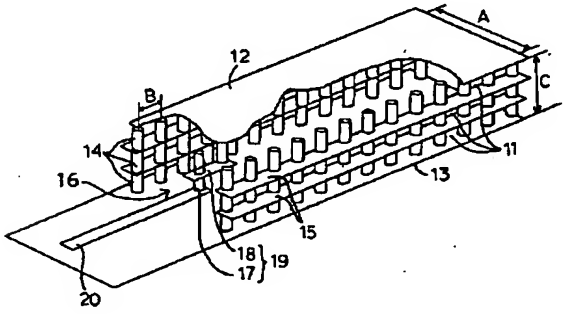
【図３】誘電体導波管線路と高周波用線路導体との接続構造における反射損失の周波数特性を示す線図である。

【図４】従来の誘電体導波管線路と高周波用線路導体との接続構造の例の概略構成を示す斜視図である。

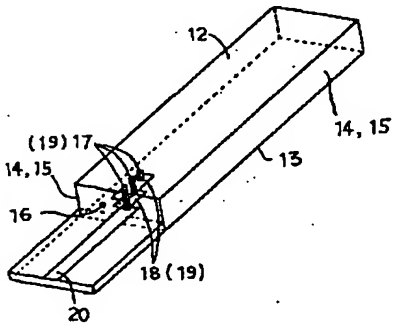
【符号の説明】

11・・・・・誘電体基板
12、13・・・主導体層
14・・・・・側壁用貫通導体群
15・・・・・副導体層
16・・・・・誘電体導波管線路
17・・・・・接続用貫通導体
18・・・・・接続用線路導体
20・・・・・高周波用線路導体

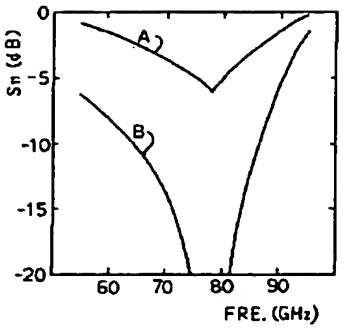
【図１】




【図２】



【図３】




【図４】